# PATENT SPECIFICATION

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## COMPLETE SPECIFICATION

## Improvements in Fluid Pressure Seal for a Rotatable Shaft

We, UNITED STATES RUBBER COMPANY, of 1230, Sixth Avenue, New York 20, United States of America, a corporation organized and existing under the laws of the State of New Jersey, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Our invention relates to a fluid pressure seal for a rotatable shaft. Although not limited to such use, our invention has been found particularly applicable as a sealing means for rotatable shafts in various types of apparatus such as rolling mills, internal mixers, gear reduction units and various rubber working machinery.

For example, in Banbury mixers and rubber mills which are used to compound rubber, the rotating parts are carried on heavy shafting of comparatively large diameters and it is necessary to seal the shafting to prevent seepage of rubber, compounding materials and carbon black from the interior to the exterior of the machinery.

It has already been proposed to provide a sealing structure for a rotatable shaft comprising an annular rubber tube seated in a recess of a supporting member surrounding the shaft, said tube having a wall adapted to apply pressure on the shaft and walls on opposite sides of said pressure applying wall extending inwardly towards the centre of the tube so that when subjected to fluid pressure they tend to deform outwardly to exert pressure on the shaft.

The present invention is characterised by the combination with an annular rubber tube as above described of spaced retaining rings seated in the recess with the annular tube therebetween, the outer diameter of the rings being substantially smaller than the diameter of the recess whereby the retaining rings may be displaced radially upon eccentric rotation of the shaft.

In the accompanying drawings, Fig. 1 illustrates one use of our invention in which the fluid pressure seal is applied to a Banbury mixer; Fig. 2 is a perspective view of the pressure tube; Fig. 3 is a perspective view of a modified form of tube; Figs. 4 to 7, inclusive, are schematic views illustrating the principles of operation of the pressure tube.

Referring to the drawing, Fig. 1 is a sectional view through part of a Banbury mixer and illustrates one use to which our fluid pressure seal may be put. In the mixer, the rotor is carried by a shaft 1 extending through an opening 2 in an end plate 3 which, in turn, is secured to the frame 4 of the mixer by bolts 5. The shaft 1 is supported in bearings, not shown. The interior 6 of the Banbury is loaded with rubber, compounding material and carbon black for mixing so that it is necessary to seal the shaft 1 to prevent these materials from migrating to the exterior of the mixer. To this end, we provide a fluid pressure seal 7 constructed in accordance with our invention which surrounds and seals the shaft 1. The seal includes a pressure tube 8 which itself extends around the circumference of the shaft and which grips the shaft or a collar 24 thereon through packing material to form a sealing means. The interior of the tube is subjected to fluid pressure, the pressure being varied according to the particular use. The tube itself is of substantially rectangular cross section the arrangement being such that it exerts a substantially uniform pressure against any surface on which it acts, in this case the packing material surrounding the shaft. The particular construction and operation of the pressure tube will now be described with reference to Figs. 4 to 7, inclusive.

Referring to Fig. 4, the tube 8 has been illustrated in schematic form to set forth

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the principles of operation. It is of substantially rectangular cross section. To this end, the tube is provided with opposite flat walls 9 and 10 and with side walls 11 and 12 which are bowed inwardly towards the centre of the tube for a purpose to be described later. The tube is located within a casing 13 which completely encloses the tube with the exception of the flat wall 9 which is left exposed so that it may rest against and bear on a flat surface 14 to form a seal therewith. The interior of the tube is subjected to fluid pressure which may be either a gas or liquid. The connection to the fluid source is made in any suitable manner as illustrated in Fig. 1. The tube wall is made of comparatively thick rubber, the thickness depending upon the amount of fluid pressure applied to the interior of the tube. It has been found that a thickness in the rubber wall of the order of one-quarter inch is suitable for use with interior fluid pressures ranging from 30 to 40 pounds per square inch; if the fluid pressure is reduced to values ranging from 10 to 20 pounds per square inch the thickness of the rubber wall may be correspondingly reduced to approximately one-eighth inch. It should be understood that the tube dimensions and the fluid pressures will vary depending upon the particular installation and that our invention is not limited to the examples given.

As already mentioned, the side walls 11 and 12 extend inwardly toward the centre of the tube to form, in effect, a bow which tends to be deflected or sprung outwardly when the interior of the tube is subjected to fluid pressure. If lines 15 are drawn from the corners of the tube to the centres of the side walls 11 and 12 it will be seen that these lines form an obtuse angle 16 and the length of the lines along the sides of the angle will be greater than the distance between the corresponding corners of the tube. Thus, when the side walls tend to move outwardly under fluid pressure there is a tendency for the angle 16 to increase. Since the rubber in the tube is incompressible, a force will be transmitted generally along the lines 15 to the corners of the tube. The pressure thus exerted at the corners of the tube by the bending or toggle action of the side walls 11 and 12 is utilized, in conjunction with the pressure exerted by the flat side wall 9, to provide a substantially uniform pressure over the entire area of the surface 14 acted upon by the pressure tube.

When the interior of the tube is subjected to fluid pressure, the pressure acting on the flat side wall 9 has been indicated by the arrows A. Since the side wall 9 is of appreciable thickness the rubber wall acts as a beam and exerts a varying amount of pressure on the surface 14 maximum at the centre and minimum at the ends, as indicated in the graphical showing of Fig. 5. Stated in other words, when the tube is subjected to fluid pressure, the flat side 9 tends to assume a circular form. It should be noted that if the pressures exerted by the flat wall alone were used to seal the surface, the pressure would not be uniform over the entire surface engaged by the pressure tube. The sealing action of the tube would be only partially effective since it would operate only over a narrow centre portion of the wall 9. This would require the use of higher pressures on the interior of the tube to provide an effective seal. To overcome this difficulty and to provide for a substantially uniform pressure over the entire surface 14 the side walls are utilized to exert pressure at the corners of the tube.

In Fig. 4, the fluid pressure in the interior of the tube acting against the side walls is represented by the arrows B. As already mentioned, the internal pressure tends to move the side walls outwardly to expand the angle 16 so that forces are transmitted generally along the lines 15 to the corners of the tube at opposite ends of the flat wall 9. The forces exerted by the side walls only are illustrated schematically by the lines B in Fig. 6.

It should be noted that the force lines of Fig. 6 are maximum at the opposite ends of the wall 9 and are at a minimum at the centre of the wall. This is substantially the reverse of the force lines A produced by the fluid pressure acting directly on the flat wall 9. Since the fluid pressure is acting on both side walls 11 and 12, as well as the flat wall 9, at the same time, the net resultant pressure exerted over the entire surface covered by wall 9 is that obtained by adding together the force lines of Figs. 5 and 6 to obtain a substantially uniform stress pattern indicated at C. in Fig. 7.

A uniform pressure over the entire surface engaged by the pressure tube is very desirable because it makes possible the use of lower fluid pressures applied to the tube to secure a good seal: it prevents entry of dirt or other contamination at the edges of the sealing means; and it reduces the frictional drag on the rotating shaft because a low uniform pressure is applied by the pressure tube over the entire area of the seal.

Fig. 2 illustrates one form of pressure tube suitable for use with a rotating shaft in which the tube is made in an endless ring. If desired, the ring may be split,

as indicated at 17 in Fig. 3 and the ends sealed off. The advantage of splitting the ring is that it may then be spread apart or deformed to facilitate installation over a shaft.

The pressure tube may be manufactured by extruding it as a hollow tube in the form shown. After extrusion the ends may be brought together and butt spliced to form an annular ring, after which the tube is vulcanized. An alternative method of manufacture is to mould the tube in two parts and then splice the parts together along the walls 9 and 10. In order to supply fluid pressure to the interior of the tube a connecting pipe or tube 18 is set into the wall 10 of the tube and is fastened to the tube in any well known manner as by vulcanizing the tube to the metal connecting pipe. The tube 8 is provided with a flange 19 surrounding the pipe 18 to strengthen the connection between the pipe and the tube. It should be manifest that the pipe 18 may extend outwardly from the tube 8 in any chosen direction depending upon the particular installation of the pressure tube. The manner in which the pressure tube is incorporated in a sealing means for a Banbury mixer will now be described with particular reference to Fig. 1.

In the pressure seal of Fig. 1, the end plate 3 of the mixer is provided with a recess or channel 20 which is closed by a cover plate 21 to form, in effect, a housing for the pressure tube. The cover plate 21 is readily removable for installation of the tube and associated mechanism; it is held in position by a plurality of bolts 22 extending around the circumference of the end plate 3. Spaced flat metal retaining rings 23 are mounted in the housing formed by the recess 20 and are of a diameter such that they fit over a collar 24 fixed to the rotatable shaft 1. Each retaining ring is provided with one or more slots 25 in the side walls thereof for receiving guide pins 26 carried by the end plate 3 and cover plate 21, respectively. The arrangement is such as to provide a pin and slot connection for the retaining rings so that they have a limited amount of movement for a purpose to be described later.

The pressure tube 8 is disposed between the retaining rings and is held in position by a separating ring 27 a portion of which extends between the retaining rings 23 to prevent them from compressing or deforming the pressure tube 8. An opening 28 is formed in the separating ring 27 for receiving the pressure supply pipe 18 and the flange 19. When installed, the pipe 18 rests in a channel 29 formed in the end plate 3; it also extends through an opening 30 in the cover plate 21 so that a suitable connection may be made to a source of fluid pressure, such as a gas or liquid (not shown). Any suitable packing, such as lead fibre rings 31 may be disposed between the bottom wall 9 of the pressure tube and the collar 24 to provide an anti-friction surface between the pressure tube and the rotating shaft. In order to lubricate the seal the collar 24 is provided with a grease well 32 into which any suitable lubricant may be forced through a lubricating nipple 33 and channel 34. A wick 35 located in a channel 36 feeds the lubricating material to the packing 31.

One of the advantages of our improved fluid pressure seal is the ease of installation and servicing. When installing the mechanism the inner retaining ring 23, which is split into two parts, is first placed in position in the recess 20 over the collar 24 and then the packing 31, pressure tube 8 and separating ring 27 are placed in position. In order to facilitate installation of the pressure tube around the collar 24 and packing 31 a vacuum may be applied to the pressure pipe 18 to partially collapse the pressure tube 8. This permits a free fit of the tube over the shaft. Thereafter the outer split retaining ring 23 and cover plate 21 are fitted in position and the cover plate secured to the end plate 3 by the bolts 22.

Another advantage of our fluid pressure seal is that the tube 8 exerts a uniform pressure over the entire surface of the packing 31 so that comparatively low fluid pressures may be utilized, for example, on the order of 20 to 30 lbs. per sq. in. This greatly reduces the amount of frictional drag imposed on the rotating shaft 1. The uniform pressure existing over the entire surface of the packing 31 effectively prevents leakage of rubber, compounding material or carbon black from the interior 6 of the mixer.

It frequently happens in mixers of the type described, that due to the heavy loading the rotating shaft 1 acquires a certain amount of eccentric movement in the bearings. Our fluid pressure seal will permit such eccentric movement of the shaft without leakage. For example, if the shaft 1 moves upwardly as it rotates, in the showing of Fig. 1, the retaining rings 23 will slide upwardly in the recess 20 such movement being provided for by the pin and slot connection 25 and 26. In this connection, it should be noted that a clearance 37 exists between the upper edges of the retaining rings 23 and the wall of the recess 20 which is at least as large as the clearance existing in the opening 2 between the

collar 24 and the end plate 3. In this way the retaining rings 28 follow the eccentric movement of the collar 24 and shaft 1 as the shaft rotates. At the same time the pressure tube 8 follows this eccentric movement simply by slight flexing in the side walls 11 and 12. The fluid pressure maintains the pressure of the tube on the packing constant at all times irrespective of any eccentric movement of the rotating shaft.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A sealing structure for a rotatable shaft comprising, in combination, a supporting member having an opening therein into which the shaft extends and a recess adjacent the opening, an annular rubber tube substantially rectangular in cross-section seated in said recess surrounding the shaft, the interior of the tube being subjected to fluid pressure, one wall of the tube being adapted to apply pressure to the shaft, the walls on opposite sides of said pressure applying wall extending inwardly towards the centre of the tube so that when subjected to fluid pressure they tend to deform outwardly to exert pressure on the surface of the shaft at opposite ends of said pressure applying wall, retaining rings in said recess surrounding the shaft and located on opposite sides of said tube, the outer diameter of the rings being substantially smaller than the diameter of said recess whereby the retaining rings may be displaced radially upon eccentric rotation of the shaft.

2. A sealing structure according to claim 1, wherein a pin and slot connection is provided between each retaining ring and the walls of the recess.

3. A sealing structure according to either of the preceding claims, wherein a cover plate is provided to close the recess.

4. A sealing structure for a rotatable shaft according to claim 1, wherein packing material is arranged between the shaft and the pressure applying wall of the annular rubber tube.

Dated this 21st day of September, 1948.

T. A. CLAYTON,
For the Applicants.

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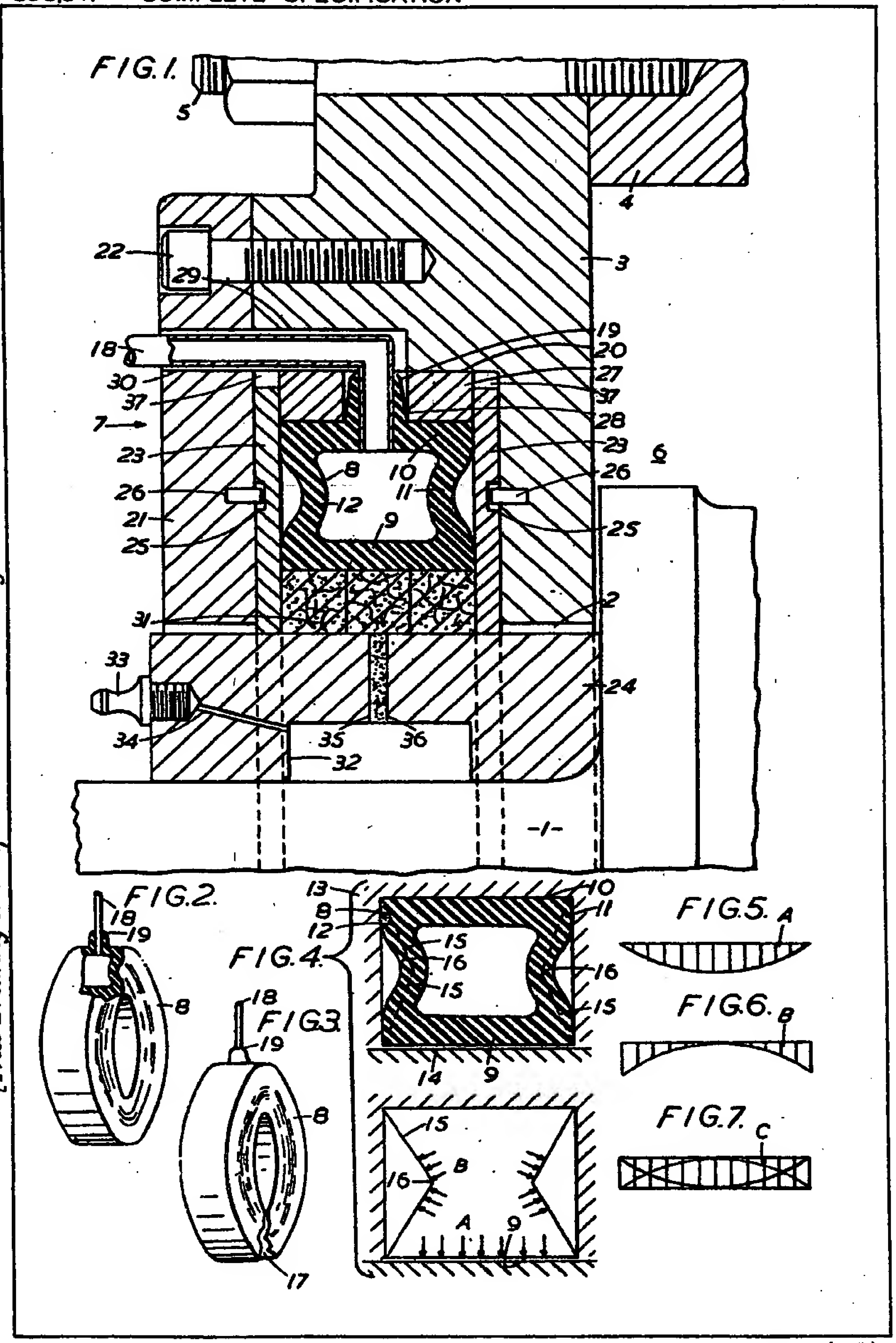


[This Drawing is a reproduction of the Original on a reduced scale.]

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